

## CLAIMS

We claim:

1. An apparatus for producing a focused audio stimulation in a maternal abdomen, the apparatus comprising:
  - an ultrasound signal generation circuit, the ultrasound signal generation circuit producing at least one ultrasound signal selected to stimulate a fetus; and
  - an ultrasound transducer circuit electrically coupled to the ultrasound signal generation circuit and acoustically coupled to the abdomen of a pregnant woman;wherein the transducer circuit receives the at least one ultrasound signal from the signal generation circuit and directs at least one focused ultrasound signal at a fetus to provide focused stimulation of the fetus.
2. The apparatus as defined in claim 1, wherein the ultrasound signal generation circuit comprises:
  - an RF generator circuit producing a carrier signal in a one to ten megahertz range;
  - an audio generation circuit, producing a signal in the audio range;
  - an amplitude modulation circuit electrically coupled to receive the carrier signal from the RF generator circuit and to receive the audio signal from the audio generation circuit, the amplitude modulating circuit modulating the carrier signal with the audio signal to produce a modulated signal.

3. The apparatus as defined in claim 1, wherein the ultrasound signal generator comprises:

a first RF generator for generating a first carrier signal at a first ultrasound frequency;

a second RF for generating a second carrier signal at a second ultrasound frequency; and

the transducer circuit comprises:

a first ultrasound stimulation transducer for receiving the first carrier signal and producing a first focused ultrasound beam directed at the fetus; and

a second ultrasound stimulation transducer for receiving the second carrier signal to produce a second focused ultrasound beam directed at the fetus;

wherein the first and second focused beams form a stimulation signal at an intersection of the focal points such that a resultant force at the intersection of the focal points vibrates the middle ear of the fetus in the audio range.

4. The apparatus as defined in claim 1, further comprising an event tracking device, the event tracking device detecting a movement of the fetus, wherein the movement of the fetus as determined by the event tracking device is correlated with the transmission of the ultrasound signal to verify the health of the fetus.

5. The apparatus as defined in claim 4, wherein the event tracking device comprises:

a fetal monitor probe acoustically coupled to the abdomen of the pregnant woman; and

a Doppler fetal monitor, electrically coupled to receive a signal indicative of motion of the fetus from the fetal monitor probe, wherein a movement of the fetus is monitored.

6. The apparatus as defined in claim 2, further comprising an event tracking device, wherein the ultrasound signal is amplitude modulated in an audio range, and the event tracking device detects a movement of the fetus correlated with the transmission of the amplitude modulated ultrasound signal to verify the hearing of the fetus.

7. The apparatus as defined in claim 6, wherein the event tracking device comprises:

a demodulator circuit electrically coupled to receive the ultrasound signal from the ultrasound signal generation circuit and to generate an audio signal;

an earphone electrically coupled to receive the audio signal from the demodulator circuit, the earphone being worn by the pregnant woman to provide an indication that the ultrasound signal has been directed at the head of the fetus;

a chart recorder; and

a marker switch electrically coupled to the chart recorder, the marker switch being selectively activated by the pregnant woman to provide an indication to the chart recorder when the pregnant woman detects a fetal movement.

8. The apparatus as defined in claim 6, wherein the event tracker comprises:  
a receiving transducer acoustically coupled to the abdomen of the pregnant woman;

a mixer circuit electrically coupled to the signal generation circuit to receive the modulated signal and to the receiving transducer to receive a reflected signal from the head of the fetus, the mixer circuit down mixing the modulated signal and the reflected signal to provide a down mixed signal; and

a low pass filter electrically coupled to the mixer circuit to receive the down mixed signal, the low pass filter filtering the down-mixed signal to detect a Doppler shift indicative of motion of the fetus.

9. A method for producing a localized sound in a maternal abdomen, the method comprising the following steps:

generating a first carrier signal at a first ultrasound frequency;

generating a second carrier signal at a second ultrasound frequency;

applying the first carrier signal to a first ultrasound stimulation transducer to produce a first focused beam; and

applying the second carrier signal to a second ultrasound stimulation transducer to produce a second focused beam;

placing the first and second ultrasound stimulation transducers on the abdomen and directing each of the first and second focused beams at a head of a fetus in utero to form a stimulation signal at the intersection of the focal points, wherein a resultant force at an intersection of the focal points of the first and second focused beams vibrates the middle ear of the fetus in the audio range.

10. The method as defined in claim 9, wherein the difference between the second ultrasound frequency and the first ultrasound frequency is a frequency in the audio range.

11. The method as defined in claim 9, further comprising the step of detecting audio-induced motion of the fetus with a Doppler motion detector.

12. The method as defined in claim 9, further comprising the steps of:  
focusing a receiving transducer for detecting signals in the same frequency range as the stimulation signal at the same location as the ultrasound stimulation transducer;  
and  
monitoring a reflected signal to detect a Doppler shift indicative of motion of the fetus.

13. A stimulation device for stimulating hearing in a fetus in utero, the stimulation device comprising:

a first RF generator generating an ultrasound signal at a first frequency;  
a second RF generator generating an ultrasound signal at a second frequency,  
the difference between the first frequency and the second frequency being in an audio frequency range;

a first ultrasound transducer electrically coupled to receive the first ultrasound signal; and

a second ultrasound transducer electrically coupled to receive the second ultrasound signal;

wherein each of the first and second ultrasound transducers are operable to convert one of the first and second RF signals to a focused beam, respectively and are positioned to direct the first and second focused beams to intersect at a position selected to stimulate the fetus.

14. The apparatus as defined in claim 13, further comprising:  
a strip chart recorder; and  
a strip chart marker switch electrically coupled to the strip chart recorder, the strip chart marker switch being selectively activated to provide an indication to the strip chart recorder when a motion of the fetus is detected.

15. The apparatus as defined in claim 13 further comprising:  
a fetal monitor probe acoustically coupled to the fetus; and  
a Doppler fetal monitor electrically coupled to receive a signal indicative of motion from the fetal monitor probe.

16. The apparatus as defined in claim 15, further comprising:  
a strip chart recorder; and  
a chart marker, the chart marker being electrically coupled to receive a signal indicative of fetal motion from the Doppler fetal monitor and to provide a signal indicative of fetal motion to the strip chart recorder when a fetal motion event is detected.